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ORIGINAL PAPER

Effects of mother tree ages, different rooting mediums, light conditions and auxin treatments on rooting behaviour of *Dalbergia sissoo* branch cuttings

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Abstract: *Dalbergia sissoo* Roxb. is one of the promising multipurpose tree species of South Asia. Most of the plantations of *D. sissoo* from seeds are facing severe threats due to the die-back disease, which ultimately causes death of this potential tree-species within a few months. Vegetative propagation could avoid the die-back disease. Thirty mother trees of different age-groups of *D. sissoo* were selected for evaluating the rooting behaviour of branch cuttings from *D. sissoo* as influenced by auxins (IAA or IBA at 100, 200, 500 mg·L^{-1}), ages of mother trees (10, 4 and 2 years old) and different environment conditions, i.e., different mediums (soil and sand) or light conditions (in shade and open condition). The results show that application of IAA and IBA induced more numbers of cuttings (collected from 10–year-old mother trees) to root compared to control. Branch cuttings of *D. sissoo* collected from 10-year-old mother trees and planted in soil bed in open conditions had 100.0% of cuttings to root in IAA (100 mg·L^{-1}) and IBA (200 mg·L^{-1}) treatments. Both rooting medium (Soil and sand) influenced significantly ($p<0.05$) on rooting response of branch cuttings. Soil medium was found to achieve maximum no. of branch cuttings to root, compared to sand medium.

Keywords: *Dalbergia sissoo*; hormonal treatments; rooting medium; shading; vegetative propagation; branch cutting

Introduction

Dalbergia sissoo is one of the most common multipurpose species with value for its timber, fodder and nitrogen fixing quality. It is distributed throughout the sub-Himalayan tract and Himalayan valleys up to 900 m at altitude (Bhatt and Verma 2002). However, most of the plantations of *D. sissoo* by the reproduction of their seeds in the past were facing severe the die-back disease problem (Tewari 1994). Vegetative propagation could, therefore, be potential means of raising *D. sissoo* plantations in order to avoid the die-back disease and other associated problems like forking in tree trunk, poor growth and lack of clean bole, etc. For many economically important tree species, vegetative propagation techniques have already been used for maintaining genetic superiority and increasing productivity (Rafiqul Hoque 2008). Further, planting materials of asexual reproduction can be raised almost throughout the year in shorter time (Libby 1974; Luna and Kumar 2006; Suresh et al. 2007). However, standardization of vegetative propagation techniques at species level is essentially required for mass multiplication of planting stock.

Ages of mother trees and auxin are the factors that influenced vegetative propagation in many economically important tree species (Bhardwaj and Mishra 2005; Hartmann et al. 2007). The growth medium and light condition were also reported to influence rooting behaviour of cuttings (Tchoundjeu et al. 2002; Shi and Brewbaker 2006). In the present investigation, an attempt was made to quantify the rooting response of branch cuttings as influenced by auxins, ages of mother trees, rooting medium and light conditions. The objective of the study was to find out the suitable optimized combination of factors for achieving optimum

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rooting ability in branch cuttings of *D. sissoo*.

Materials and methods

Effect of age of mother trees and auxin treatments on rooting response of branch cuttings

Thirty mother trees of different age-groups of *D. sissoo* were identified and tagged in the experimental garden of Department of Forestry, H.N.B. Garhwal University, Srinagar Garhwal, Uttarakhand, India (30°78'E; 17°30'N, and 500 m a.s.l. at altitude) in Feb., 2003. A total of 1 260 healthy branch cuttings of uniform size (25–30 cm in length and 1.2–1.5 cm in diameter) were collected from 10-, 4- and 2-year-old Candidate Plus Trees (CPTs) in first week of March for recording the effects of ages of mother tree and auxin treatments on rooting behaviour of branch cuttings. Basal 5-cm portion of the cuttings was dipped into Indole 3-acetic acid (IAA) solutions at 100, 200 and 500 mg·L^{-1} for 24 h. Other set of cuttings was treated with 100, 200 and 500 mg·L^{-1} of Indole 3-butyric acid (IBA). Cuttings treated with double distilled water were considered as control. Prior to hormonal treatment, all the sets of cuttings were dipped in the Dithane M-45 solution for 2 min to avoid the fungal infection.

The treated cuttings were planted in polybags, filled with the sterilized sand and soil, and farmyard manure in 1:1:1 ratio. Polybags were placed in the net house of experimental farm in randomized block design. One cutting was planted in each bag. A total of 420 nos. of branch cuttings were collected in three replications by allotting 20 cuttings in each replicate. After 90 days, observations on sprouting-rooting ratio, average root-sprout no/cutting and average root-sprout length per cutting were conducted for each set. Test of significance was computed to observe the significant variations between treatments at 5% level of probability (Sharma 1998).

Effect of light conditions

A total of 420 branch cuttings were planted in open condition with solar light in three replications by allotting 20 cuttings in each replicate. Shade was provided to the cuttings by using nylone mesh inhibiting 25% of the solar radiations. The branch segments were exogenously treated with auxins before planting either in open or shade. Control set of cuttings was treated with double distilled water. The cuttings were planted in randomized block design. All the cuttings were planted in polybags filled with sand, soil and farmyard manure in 1:1:1 ratio.

Effect of rooting medium

The 420 cuttings of *D. sissoo* were planted in soil. Likewise, 420 cuttings were also planted in sand. The soil medium was consisted of sand, soil and farmyard manure in 1:1:1 ratio. For preparing the sand medium, sand collected from the river beds was washed thoroughly, sieved and sterilized. Since, water holding capacity of sand medium was very less, frequent irrigation was given to the cuttings in order to maintain the moisture in polythene bags in net house condition.

Results

Effect of ages of mother tree and auxin treatments on rooting response of branch cuttings

The results revealed that rooting response was significantly ($p < 0.05$) influenced by ages of mother trees. The highest rooting and sprouting percentage was 85.0% when cuttings were collected from 4-year-old mother trees in 500-mg·L^{-1} IAA treatment (Table 1). The lowest rooting and sprouting percentage was 15.0% in branch cuttings collected from 2-year-old mother trees in 200-mg·L^{-1} IAA treatment. Control set of branch cuttings collected from 10-year-old mother trees showed 55.0% of rooting and sprouting percentage. The maximum ratio of sprout to sprouted cutting in branch cutting collected from 2 and 4 years old mother trees in 500-mg·L^{-1} IAA treatment was 2.8, 3.6, respectively. The maximum sprout length was 19.5 cm in branch cuttings from 4-year-old mother trees in 100-mg·L^{-1} IBA treatment. Similarly, highest ratio of root to rooted cuttings and root length were 21.7 and 12.4 respectively in branch cuttings from 10-year-old mother trees in 500-mg·L^{-1} IAA treatment (Table 1).

Effect of light conditions

The percentage of rooting was successfully achieved for 100% in branch cuttings of IAA treatments at 200, 500 mg·L^{-1} in the shade. In control set of branch cuttings in shade, sprouting and rooting percentage was 50.0% and 30.0%, respectively (Table 2). In open condition, sprouting and rooting percentage of branch cuttings was 100.0% in IAA treatment of 100 mg·L^{-1} and 200 mg·L^{-1}. In open condition, sprouting and rooting percentage of the branch cuttings with 200-mg·L^{-1} IBA treatment was 100.0%, which also had rooting percentage of 90.0% successfully in control. On an average, exogenous application of 200-mg·L^{-1} IAA induced maximum rooting percentage of branch cuttings either in open or shade condition. The maximum ratio of sprout to sprouted cutting was 8.0 in open condition and in 100-mg·L^{-1} IAA treatment. In shade condition, maximum ratio of sprout to sprouted cutting was 4.4 in 100-mg·L^{-1} IAA treatment. The highest sprout lengths of branch cuttings treated with IAA at 500, 200 mg·L^{-1} in shade and open condition were 11.5 cm and 7.4 cm respectively. However, maximum ratio of root to rooted cutting was 36.7 in branch cuttings of 500-mg·L^{-1} IBA treatment in shade condition and 22.5 in 500-mg·L^{-1} IAA treatment in open condition. The maximum average root length was 12.1 cm and 9.0 cm, respectably in branch cuttings of 100-mg·L^{-1} IAA treatment in shade and 100-mg·L^{-1} IBA treatment in open condition (Table 2).

Table 1. Effect of mother tree ages and auxin treatments on vegetative propagation in *D. sissoo* branch cuttings

Treatments	Age (year)	Sprouting percentage (%)	Rooting percentage (%)	Ratio of sprouts to sprouted cutting	Sprout length (cm)	Ratio of roots to rooted cutting	Root length (cm)
Control		0.00^{e}	0.00^{d}	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{c}
100 mg·L^{-1} IAA		25.0^{bc}	25.0^{b}	1.8±1.0^{b}	5.7±1.9^{ab}	2.3±0.6^{d}	3.2±1.1^{b}
200 mg·L^{-1} IAA		35.0^{b}	25.0^{b}	2.5±21^{a}	11.8±5.9^{b}	9.5±3.6^{bc}	3.8±1.8^{b}
500 mg·L^{-1} IAA	2	50.0^{a}	50.0^{a}	2.8±1.8^{a}	15.2±6.9^{ab}	13.8±10.9^{a}	8.7±3.6^{a}
100 mg-L-^{1} IBA		25.0^{bc}	25.0^{b}	1.8±1.5^{b}	5.5±3.3^{c}	8.5±8.3^{c}	3.8±2.7^{b}
200 mg-L-^{1} IBA		15.0^{d}	15.0^{c}	2.2±0.8^{a}	15.1±3.0^{ab}	11.1±7.9^{a}	8.6±3.11^{a}
500 mg-L-^{1} IBA		20.0^{cd}	20.0^{bc}	2.7±0.8^{a}	19.0±13.0^{a}	10.3±3.0^{ab}	7.5±1.4^{a}
Control		0.00^{d}	0.00^{d}	0.00^{d}	0.00^{e}	0.00^{d}	0.00^{e}
100 mg·L^{-1} IAA		25.0^{c}	25.0^{c}	2.0±1.2^{ab}	8.6±3.5^{cd}	5.5±0.^{7cd}	2.3±2.1^{d}
200 mg·L^{-1} IAA		25.0^{c}	25.0^{c}	2.7±0.6^{a}	5.6±3.8^{d}	2.5±2.1^{cd}	8.9±1.6^{a}
500 mg·L^{-1} IAA	4	85.0^{a}	85.0^{a}	3.6±1.5^{a}	13.6±3.1^{b}	18.7±9.9^{a}	5.3±2.1^{bc}
100 mg-L-^{1} IBA		50.0^{b}	50.0^{b}	2.0±0.8^{c}	19.5±2.19^{a}	13.0±3.2^{b}	5.0±2.5^{bc}
200 mg-L-^{1} IBA		50.0^{b}	50.0^{b}	3.3±0.6^{ab}	10.7±5.8^{bc}	8.7±7.7^{c}	3.5±2.2^{cd}
500 mg-L-^{1} IBA		60.0^{b}	60.0^{b}	2.5±0.7^{bc}	12.8±5.6^{bc}	9.7±2.3^{c}	6.7±1.5^{b}
Control		55.0^{cd}	55.0^{cd}	2.6±0.98^{a}	7.4±6.41^{c}	8.3±4.16^{cd}	5.6±4.07^{e}
100 mg·L^{-1} IAA		60.0^{bc}	60.0^{bc}	3.6±1.03^{a}	13.6±6.50^{b}	4.5±2.26^{d}	11.8±3.44^{bcd}
200 mg·L^{-1} IAA		65.0^{b}	65.0^{b}	2.8±0.75^{c}	18.5±16.30^{a}	11.2±6.49^{bc}	10.1±5.02^{cd}
500 mg·L^{-1} IAA	10	75.0^{a}	75.0^{a}	3.2±0.98^{b}	12.2±8.21^{b}	21.7±8.50^{a}	12.4±5.84^{bc}
100 mg-L-^{1} IBA		60.0^{bc}	60.0^{bc}	2.8±0.75^{c}	13.3±7.26^{b}	10.7±6.92^{bc}	16.3±6.98^{a}
200 mg-L-^{1} IBA		65.0^{b}	65.0^{b}	2.6±1.37^{c}	8.1±4.67^{c}	6.7±4.83^{c}	12.9±4.16^{b}
500 mg-L-^{1} IBA		50.0^{d}	50.0^{d}	3.5±2.07^{a}	5.9±2.03^{c}	8.3±14.56^{cd}	9.7±1.20^{d}

Notes: Mean values followed by the same letter are not significantly ($p < 0.05$) different within age groups of different treatments. The +/- values are the standard deviations in a particular treatment.

Table 2. Effect of light conditions and auxin treatments on vegetative propagation in *D. sissoo* branch cuttings collected from 10-year-old mother trees

Treatments	Light condition	Sprouting percentage (%)	Rooting percentage (%)	Ratio of sprouts to sprouted cutting	Sprout length (cm)	Ratio of roots to rooted cutting	Root length (cm)
Control		50.0^{b}	30.0^{b}	2.8±1.09^{b}	4.5±2.81^{c}	5.0±1.41^{b}	7.1±4.59^{bcd}
100 mg·L^{-1} IAA		95.0^{a}	90.0^{a}	4.4±2.61^{a}	5.7±1.68^{c}	4.4±3.4^{b}	12.1±4.01^{a}
200 mg·L^{-1} IAA		100.0^{a}	100.0^{a}	2.6±10.82^{b}	9.7±6.33^{ab}	13.8±9.3^{b}	8.0±1.32^{b}
500 mg·L^{-1} IAA	Shade	100.0^{a}	100.0^{a}	2.5±1.05^{b}	11.5±9.54^{a}	36.5±15.4^{a}	8.5±1.58^{b}
100 mg-L-^{1} IBA		90.0^{a}	90.0^{a}	2.2±1.17^{bc}	3.9±2.20^{c}	8.5±4.64^{b}	5.6±2.68^{d}
200 mg-L-^{1} IBA		90.0^{a}	90.0^{a}	2.3±1.63^{b}	5.3±3.34^{c}	9.7±5.32^{b}	6.0±2.53^{cd}
500 mg-L-^{1} IBA		90.0^{a}	90.0^{a}	1.7±0.41^{c}	8.0±2.93^{b}	36.7±16.4^{a}	7.4±1.82^{bc}
Control		100.0^{a}	90.0^{b}	5.5±1.05^{b}	5.9±2.09^{c}	12.3±6.7^{b}	4.8±1.27^{c}
100 mg·L^{-1} IAA		100.0^{a}	100.0^{a}	8.0±1.55^{a}	5.9±0.75^{c}	7.4±3.99^{c}	6.6±2.06^{ab}
200 mg·L^{-1} IAA		100.0^{a}	100.0^{a}	5.0±1.79^{b}	7.4±2.37^{a}	16.7±6.3^{b}	8.8±4.23^{a}
500 mg·L^{-1} IAA	Open	95.0^{b}	95.0^{b}	5.8±3.96^{b}	6.1±2.58^{bc}	22.5±16.4^{a}	7.5±4.92^{b}
100 mg-L-^{1} IBA		95.0^{b}	70.0^{c}	5.7±2.06^{b}	6.3±2.68^{bc}	6.8±4.11^{c}	9.0±4.54^{a}
200 mg-L-^{1} IBA		100.0^{a}	100.0^{a}	5.2±3.60^{b}	5.9±3.24^{c}	13.3±9.6^{b}	8.2±2.71^{ab}
500 mg-L-^{1} IBA		95.0^{b}	95.0^{b}	2.5±1.52^{c}	4.9±1.95^{d}	15.5±10.4^{b}	6.4±0.98^{b}

Notes: Mean values followed by the same letter are not significantly ($p < 0.05$) different within light condition of different treatments. The +/- values are the standard deviations in a particular treatment.

Effect of rooting medium

Auxin-treated branch cuttings were planted in rooting medium with sand or soil. The data revealed that branch segments planted in soil medium had higher rooting percentage, compared to that in sand medium (Table 3). On an average, sprouting and rooting percentage was 100.0% when branch cuttings of 200-mg·L^{-1} IAA treatment were planted in soil medium. The maximum cuttings (75.0%) in sand medium were sprouted and 65.0% of cuttings were rooted in 500-mg·L^{-1} IBA treatment. Control set of cuttings had more rooting rate in soil medium whereas, cuttings planted in sand medium failed completely to root. The maximum ratio of

sprout to sprouted cutting was 6.0 in 500-mg·L^{-1} IBA treatment in soil, while in sand medium it was 4.5 in 500-mg·L^{-1} IAA treatment. The maximum sprout length was 15.4 cm in branch cuttings of 200-mg·L^{-1} IAA treatment in soil medium, and it was 7.3 cm also in 500-mg·L^{-1} IAA treatment. The highest ratio of root to rooted cutting was 30.0 in 100-mg·L^{-1} IAA treatment in sand medium; however, in sand medium it was also 18.4 in 500-mg·L^{-1} IAA treatment. The maximum root length was 11.1 cm in 200-mg·L^{-1} IBA treatment in sand medium. In soil medium, maximum root length was 9.5 cm in 100-mg·L^{-1} IAA treatment. Growth medium caused significant (p<0.05) variations in rooting response of branch cuttings (Table 3).

Table 3. Effect of potting medium and auxin treatment on vegetative propagation in *D. sissoo* branch cuttings collected from 10–year-old mother trees

Treatments	Medium	Sprouting percentage (%)	Rooting percentage (%)	Ratio of sprout to sprouted cutting	Sprout length (cm)	Ratio of roots to rooted cutting	Root length (cm)
Control	Sand	0.00^{e}	0.00^{d}	0.00^{e}	0.00^{c}	0.00^{d}	0.00^{e}
100 mg·L^{-1} IAA		15.0^{d}	15.0^{c}	2.0±1.13^{d}	3.9±1.12^{d}	30.0±1.05^{a}	6.3±3.24^{cd}
200 mg·L^{-1} IAA		40.0^{b}	40.0^{b}	3.7±0.58^{ab}	15.4±3.50^{a}	7.0±2.58^{c}	7.3±3.06^{bc}
500 mg·L^{-1} IAA		40.0^{b}	40.0^{b}	4.5±1.71^{a}	6.9±1.92^{b}	11.5±2.71^{b}	8.0±1.58^{bc}
100 mg-L-^{1} IBA		50.0^{b}	50.0^{ab}	2.7±0.58^{bc}	13.1±3.55^{a}	11.0±3.00^{b}	9.6±2.22^{ab}
200 mg-L-^{1} IBA		35.0^{b}	35.0^{b}	2.3±1.15^{c}	11.5±3.50^{a}	3.7±2.52^{d}	11.1±3.65^{a}
500 mg-L-^{1} IBA		75.0^{a}	65.0^{a}	2.3±0.58^{c}	7.4±6.52^{b}	12.0±3.0^{b}	4.0±1.44^{d}
Control	Soil	75.0^{b}	60.0^{d}	3.4±1.24^{e}	5.2±2.05^{d}	8.4±3.01^{c}	5.1±2.97^{d}
100 mg·L^{-1} IAA		95.0^{a}	95.0^{a}	4.7±2.01^{b}	5.8±1.29^{c}	5.5±1.92^{c}	9.5±1.90^{a}
200 mg·L^{-1} IAA		100.0^{a}	100.0^{a}	4.4±1.90^{bc}	6.5±1.70^{b}	10.0±2.12^{c}	8.5±2.14^{abc}
500 mg·L^{-1} IAA		100.0^{a}	95.0^{a}	4.3±1.29^{bc}	7.3±2.67^{a}	18.4±2.19^{b}	8.0±3.05^{c}
100 mg-L-^{1} IBA		95.0^{a}	80.0^{c}	3.7±1.64^{cde}	6.1±1.58^{bc}	7.1±1.29^{c}	8.2±2.12^{bc}
200 mg-L-^{1} IBA		100.0^{a}	80.0^{c}	5.8±1.97^{a}	6.0±2.49^{c}	10.1±2.09^{c}	8.3±2.85^{bc}
500 mg-L-^{1} IBA		100.0^{a}	85.0^{bc}	6.0±2.42^{a}	6.1±2.04^{bc}	24.1±1.27^{a}	9.1±3.12^{ab}

Notes: Mean values followed by the same letter are not significantly (p<0.05) different within medium of different treatments. The +/- values are the standard deviations in a particular treatment.

Discussion

To produce the genetically superior trees, vegetative propagation is one of most successful techniques in many economically important trees including *D. sissoo*. Present investigation reveals that ages of mother tree significantly (p < 0.05) influenced the rooting behaviour of cuttings. Branch segments collected from 10-year-old trees triggered maximum number of cuttings to root. Various researchers have also proved that there are more cuttings from mature trees to root than those from juvenile trees, however, it is the species specific (Rafiqul Hoque 2008; Puri and Verma 1996; Andres et al. 1999).

D. sissoo exhibited more rooting rate with exogenous application of auxins. Nevertheless, control set of branch cuttings had fair success in rooting rate. In control set of cuttings, average rooting percentage of branch cuttings from 10-year-old mother trees was recorded to be 59.0% which is quite comparable with rooting potential of auxin-treated cuttings (Rana et al. 1987). In case of *D. sissoo*, rooting could be obtained even during low temperature months (Oct.-Feb.) with the application of auxins, however, control set of cuttings failed completely to root (Rana et al. 1987).

Cuttings planted in open exhibited optimum success in rooting, compared to those planted in shade condition. Control set of cuttings in open and shade showed rooting percentage from 90.0% to 30.0%, respectively. It is also added advantage to the resource poor farmers since they can plant the cuttings in open fields without application of hormones. On average, soil medium significantly improved the rooting ability of cuttings, compared to sand medium. In soil medium, all the parameters for rooting behaviour of cuttings showed higher values except for shoot length. Control set of cuttings had the profused rooting rate in soil medium whereas, cuttings planted in sand medium failed completely to root. These variations might be related to either their different water holding capacities or available nutrients to the adventitious roots (Tchigio and Duguma 1998). In the present study, sand medium had almost negligible water holding capacity, which probably created physiological stress at lower end of branch cuttings.

Conclusions

D. sissoo could be successfully multiplied through branch cuttings. However, to obtain the highest rooting rate, mature branch cuttings should be planted in open condition in soil medium. Exogenous application of IAA solution at 200 and 500 mg·L^{-1} was most suitable to induce higher rooting rate for cuttings planted in shade condition. However in open condition, application of IAA at 100 and 200 mg·L^{-1} and IBA at 200 mg·L^{-1} can produce more rooting percentage. The average rooting percentage ranged from 30.0% to 90.0% in control set of branch cuttings

in shade and open. The branch cuttings from different age mother tree (2, 4, 10 years old) produced maximum rooting percentage in 500-mg·L^{-1} IAA treatments. This technology would help to a great extent to the nursery growers to produce quality planting material of *D. sissoo*.

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